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Learners’ Conceptions of Techno-Risk Tolerance

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Abstract

The research task was to explore learners’ conceptions of risk in Technology Education (TE) using the Techno-Risk Tolerance Questionnaire (T-RTQ). As zero risk is impossible to achieve some risk must be tolerated. Knowledge and understanding of technological production activities and sciences are needed in defining a tolerable level of risk. The teacher has a responsibility to guide learners in avoiding harmful risks while encouraging them to take beneficial risks. Success in production activities encourages learners towards new challenges while the risk of failing is set into right proportion. Innovative production activities include taking ingenious risks when exploring the limits and potential of the individual as well as the surrounding environment.

The conceptions of learners were assessed using the T-RTQ. The participants (n = 102) were 9th grade pupils of TE in compulsory education schools in Southern and Western Finland. The analysis took place in two phases. First, the internal consistency of the T-RTQ was tested and secondly, the results were compared to a previous survey n = 120 (subsample of 393 total). The fit indexes showed good fit between the model and the data. Techno-Risk Tolerance was measurable with the T-RTQ. Techno-Risk can be increasingly hidden in embedded systems and networks so pupils require more education in risk awareness in their technological activities. Further research should be carried out on both beneficial and harmful risks in order to avoid over-emphasizing harmful risks. The key ideology of the late 20th century Safety Education was achieving zero risk but Safety Education of the 21st century should be aimed to educate to prepare for uncertainty of Techno-Risk.

Keywords: Techno-Risk, Techno-Risk Tolerance Questionnaire (T-RTQ), Safety Education

Introduction

In the late 20th century, pursuing safety was adored in society. The development culminated into the idea of absolute safety, the so called Zero Risk Ideology which finally led to avoiding Techno-Risk and taking responsibility of it which then made Techno-Value difficult to achieve. As zero risk is practically impossible to achieve, safe can't mean the same as harmless. However, this was a popular definition until recently (Reason, 2008, 265; comp. Shrader-Frechette, 2003, 188–189). Uncertainty means that the break of safety is always possible (Hansson, 1999, 539). Techno-Risk Tolerance is required to continue action despite of the uncertainty.

One of the research tasks of this study was to re-test the Techno-Risk Tolerance Questionnaire (T-RTQ). The questionnaire was developed and modelled in the Safety Sense Project (Kallio, 2014) with a series of measurements representing the key-elements of learners' conceptions of Techno-Risk Tolerance. Other questionnaires of the Safety Sense Project were the Risk-Responsibility Questionnaire, the Techno-Value Questionnaire, the Techno-Risk Questionnaire and the questionnaires of risk covers and risk revealers, all with the same variables.

Learner-Centred Learning takes place when education focuses on survival in the technological world and constructing an even more viable technological life-world. Achieving innovativeness requires taking risks as innovativeness and risk are inter-correlated. The learner explores the limits and potential of him/herself and the surrounding environment when he/she tests new ideas. In a learner-centred culture, the learner must take ingenious risks as success is not certain. Even though the teacher has the responsibility to guide learners in avoiding harmful risks, ultimately the learner makes his/her own decisions on the risks at hand. The teacher's instructions and answers encourage and limit the potential of the learner but the learner's conception of his/her own Techno-Risk Tolerance is the determining factor when exploring the technological world.

The research questions were:

1. Is the Techno-Risk Tolerance Questionnaire (T-RTQ) valid and reliable for measuring learners' conceptions of Techno-Risk Tolerance?
2. What kind of conceptions of Techno-Risk Tolerance do learners have compared to previous results?

Theoretical Background

The presence of risks increase as the value achievable through technological activities increases or decreases – Techno-Risk increases as Techno-Value increases but aiming for lower Techno-Value also increases Techno-Risk. Therefore, both should be optimized. Technological production activities increase well-being as long as Techno-Risk remains below Techno-Value (see marked area in figure 1).

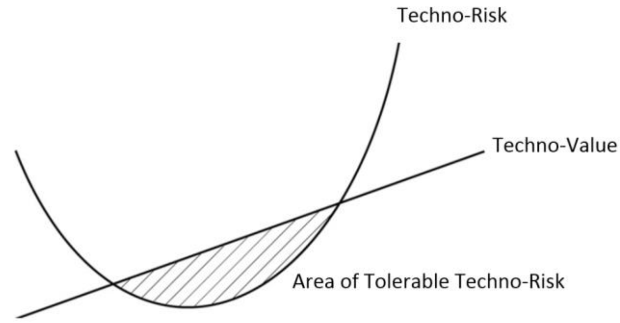


Figure 1. The Area of Tolerable Techno-Risk (Kallio, 2014).

As the level of safety approaches zero, the risk of a safety breach increases infinitely. This is the Highest Tolerable Level of Risk (HTLR). At this point, it is no longer worthwhile to pursue Techno-Value further at the expense of Techno-Risk increasing. On the other hand, aiming for minimal Techno-Risk means lower Techno-Value. If a low level of Techno-Value is aimed for, Techno-Risk will increase before the HTLR is ever reached. New risks are faced when pursuing safety through reducing activity. Both ends of the scale are open and safety leads to well-being.

Technology Education (TE) includes a proportional amount of risk. If no value can be gained from an activity, no risk should be taken but if great value can be achieved, a higher level of risk should be tolerated. The HTLR is determined again and again as production activities progress or as new tasks are started.

A tolerable level of risk is not the same as an acceptable level of risk and risks should still be reduced (Hollander, 1997, 112). A tolerable level of risk can't be measured but must be decided (Lowrance, 1976, 75–76) which leads to ethical considerations (Shrader-Frechette, 1992; Hansson, 1999, 542). The tolerable level of risk in TE is determined by comparing the value that may be achieved through production activities and the probabilities of risks that may rise from the activities. The learner's possibilities to participate in society and to use technology in their lifelong learning should also be taken into consideration. Generally, taking controlled risks in school is safer than facing the same risks in less controlled environments later in life.

The risks within TE can be assessed both qualitatively and quantitatively. The qualitative dimension represents the severity of the outcomes of risks while the quantitative dimension represents the probabilities of the risks. Risks can be comprised of many different, possibly risk-free components that together form an unbearable risk. A quantitatively measurable risk can be so improbable that it becomes statistically insignificant (Shrader-Frechette, 2003, 188–189). The quality of risk should be assessed subjectively when the probability of a risk can't be determined (Shrader-Frechette, 1992). Subjective assessment means that every learner has their own conception of a tolerable level of risk. Whether risks are assessed according to speed, costs, productivity or Techno-Value, the subjective level of risk is always a compromise. The risks within technological production activities should always be assessed by the learners themselves.

Methods

Participants

The Techno-Risk Tolerance Questionnaire (T-RTQ) was originally tested in Finland with a nation-wide sample with 6th and 9th grade pupils from both rural and city environments as well as small and large schools (n = 393). The data consisted of a sub-sample of 9th grade technical technology pupils (n = 120) (Kallio, 2014). The sample (n = 102) of this research included 9th grade pupils from a large school in Southern Finland and from a small school in Western Finland.

Measures

The T-RTQ is a method of measuring within the Risk-Responsibility Model. Learners' conceptions of risk are presented in the model with Techno-Risk Tolerance as the dependent factor (figure 2).

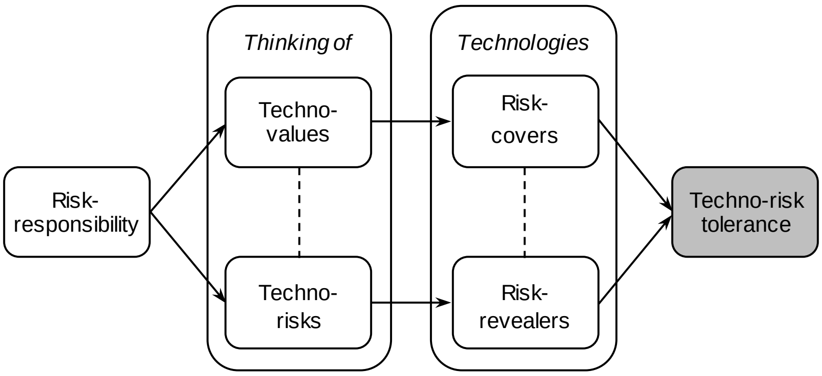


Figure 2. The Risk-Responsibility Model (Kallio, 2014).

The model was confirmed using Structural Equation Modelling. The path model fit the data (χ^2(df) = 7.61(5); RMSEA = .04; CFI = .995; TLI = .985; SRMR = .02) and the model explained 35 % of variable variation in the whole sample of learners of Technology Education (n=392). This can be considered a very high rate. The rate was up to 39 % in the sub-sample of 9th grade pupils (n = 120). (Kallio, 2014).

In the present study, the T-RTQ was re-tested and learners' conceptions were assessed with the new data of 9th grade pupils (n=102). The factors were set according to the theory of the reality network, adapted to TE (Kallio, 2014) from Bruno Latour (2003). The dimensions of the network are the learner's internal and external reality (the mind and nature) and scientific and religious or ideological believes (society and god). The dimensions were adapted to TE and cross-tabulated with technological processes, technological products, technological skills and technological resources. This produced the dimensions Succeeding & Skilfulness, Reputation & Distinction, Innovativeness & Effectiveness, Environment & Sustainability and Well-Being & Safety. While each factor consisted of three variables, the original series of measurement consisted of 123 items and the compressed version had 66 items. To limit the amount of items, the T-RTQ had nine items in total. The dimension of Safety was not included in the T-RTQ as all the other dimensions were scaled against it to determine how high risks learners were ready to take to achieve Techno-Value within each dimension.

Procedure

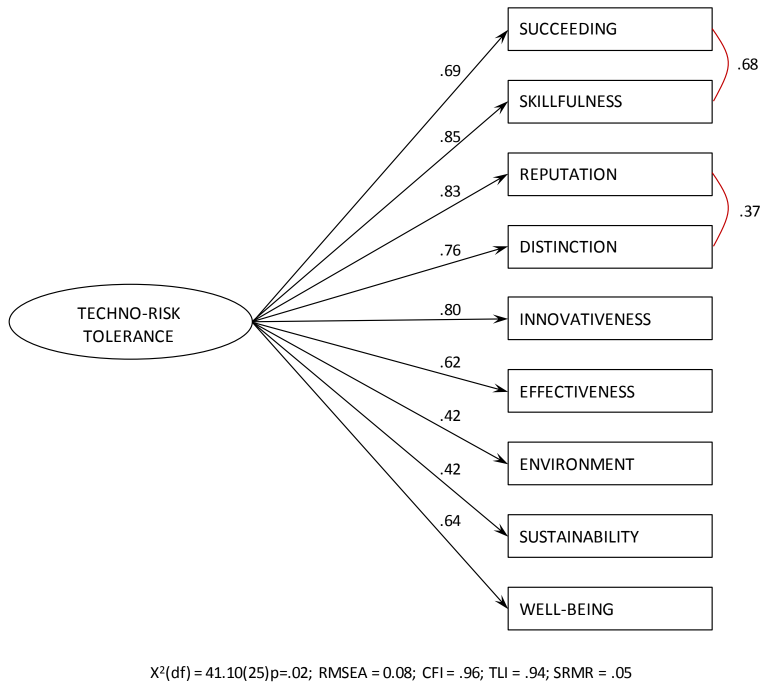
The assessment was done in two phases. First, the internal consistency of the T-RTQ was assessed using Confirmatory Factor Analysis (CFA) and Cronbach's (1951) Alpha was calculated. Then, the new results were compared with the previous ones (Kallio, 2014).

Table 1. The descriptive statistic of the Techno-Risk Tolerance Questionnaire (T-RTQ).

THE TECHNO-RISK TOLERANCE QUESTIONNAIRE

	M	SD	Skewness	Kurtosis	
Environment	3.41	1.14	-.42	-.36	I would not risk my safety for the environment.
Sustainability	3.24	1.18	-.25	-.65	I would not risk my safety to save natural resources or energy.
Reputation	2.79	1.17	.22	-.66	I would not risk my safety to make other learners admire me.
Distinction	2.99	1.21	-.05	-.82	I would not risk my safety to produce a product that the other learners admire.
Effectiveness	3.25	1.17	-.23	-.70	I would not risk my safety to save time.
Innovativeness	3.03	1.16	-.14	-.59	I would not risk my safety to complete a new invention.
Skilfulness	2.78	1.10	.17	-.54	I would not risk my safety to learn a new skill.
Succeeding	3.13	1.17	-.10	-.56	I would not risk my safety to finish my task.
Well-being	2.75	1.20	.19	-.68	I would not risk my safety to do something I enjoy doing.

The matrix was suitable for CFA as the skewness and kurtosis of the distribution of each variable was between -1 and +1 (Tähtinen, Laakkonen & Broberg, 2012, 74–75). CFA was used to confirm construct validity of the measurement based on the theoretical setting. In CFA, the researcher determines the factor structure. That is, identifies each variable with a factor (Hoyle, 2012; Cooper, 2006, 863). The factor structure is then used to evaluate the validity of the model (Brown & Moore, 2012; Curran, West & Finch, 1996). Determining a tolerable level of risk was based on a previously confirmed theory so in this research, CFA was used to confirm internal consistency of the model with the new sample.



MLR estimation (Mplus 6.11 Structural Equation Modelling Software)
Factor loadings are all significant (p < .001)

*Figure 3***.** *Confirmatory Factor Analysis (CFA) of the Techno-Risk Tolerance Questionnaire (T-RTQ).*

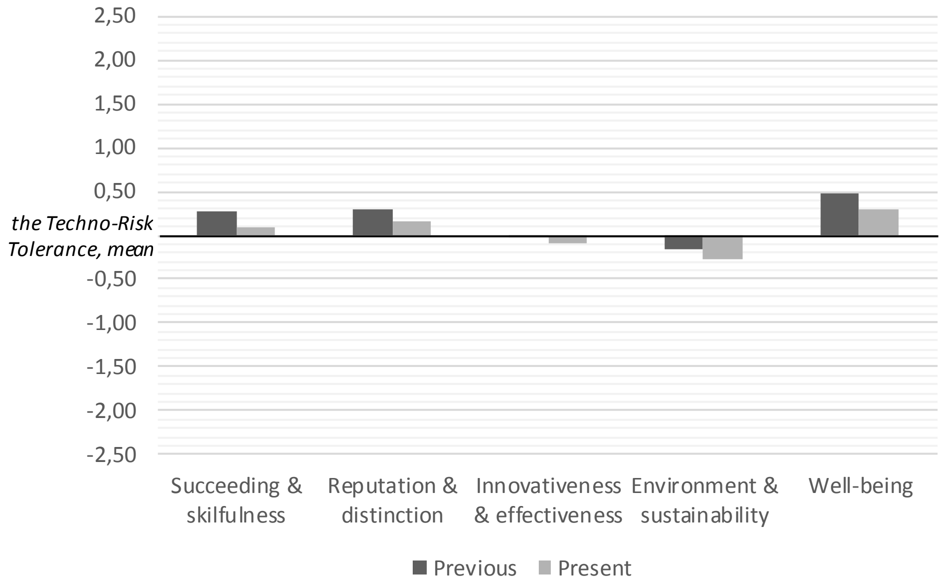
Results

Question 1

The model fit the data well (χ^2(df) = 41.10(25); RMSEA = .08; CFI = .96; TLI = .94; SRMR = .05). The χ^2 -test revealed better fit of the factor structure than in the previous study (χ^2(df) = 53.29(25, n = 393) p = .001). However, the χ^2 -test is sensitive to sample size. The other indexes had slightly higher values than in the previous measurement (RMSEA = .05; CFI = .98, TLI = .97; SRMR = .03). The difference in sample size could explain these differences. The factor loadings weren't in line for all the factors but none of the factors could be excluded as they all measured a different dimension of Techno-Risk Tolerance. Connections between the factors were added according to theory and the results of the previous studies. The fact that some factors had lower values did not affect model fit. The factor loadings were all statistically highly significant (p < .001). Since the Cronbach's Alpha for the T-RTQ is .89 (n = 102), the measurement was found reliable. The Confirmatory Factor Analysis (CFA) confirmed that the factor structure fit the data revealing the validity of the questionnaire. The Techno-Risk Tolerance was confirmed to be measured using the T-RTQ.

Question 2

The results revealed that the T-RTQ produces consistent measurements within different samples.



The differences in learners' conceptions on a five point scale.
Zero-level was set at the Mean of the present data (see table 1).

Figure 4. Learners' Conceptions of the Factors of Techno-Risk Tolerance.

The values for learners' conceptions of Techno-Risk Tolerance within each factor were systematically slightly higher in the new data compared with the previous study. Statistically however, the Means didn't differ (t-test, $p > .05$, all factors). The results were similar between the samples with each factor which shows that the T-RTQ provides consistent results. The previous study showed that the differences between the factors were more significant when measured without the learners considering the relation between the benefits of taking risk and safety (Kallio, 2014). While the learners avoided risk in some activities, they were ready to take more risk in others. The consistent new results confirm validity of the T-RTQ.

Limitations of the study

The narrow sample does not make it possible to generalize results on learners' conceptions of Techno-Risk Tolerance but the T-RTQ has been tested on a larger sample previously. The new results were consistent with the previous ones so the new results can be considered reliable. The dimensions of the T-RTQ couldn't be used as factors directly. A small number of factors is usually considered a sign of a good measure. Internal consistency of the T-RTQ was good and the new results were in line with previous ones so the results can be considered valid.

Even though the dimensions were divided into factors, the T-RTQ is limited in differentiating the dimensions of Techno-Risk Tolerance but the values varied for each dimension. Techno-Risk Tolerance was most meaningful with Skilfulness, Reputation, Innovativeness, Distinction and Succeeding. It was the least meaningful with Environment and Sustainability. The T-RTQ is better for measuring within the dimensions that had the higher values. It could be that Technology Education (TE) is not as strongly related to the dimensions with the lower values or that the learners simply didn't consider these dimensions to be related with the risks they took.

Discussion

At the end of the last century and until recent years, risks were avoided with the aim for zero risk. This led to avoiding beneficial risks as well. While Safety Education and learning environments have developed, it has been forgotten that safety is a part of well-being. Well-being can’t be developed without taking productive risks. Therefore, Safety Education should educate learners to take responsibility for their own Techno-Risk Tolerance.

Techno-Risk and Techno-Value have not been taken into due consideration. This has led to a decrease in responsibility over Techno-Risk Tolerance. As well as the learners, also teachers and schools should assess the ratio. The purpose of this research was to assess learners’ conceptions of Techno-Risk Tolerance. The results showed that the T-RTQ is a consistent measure and can be used for larger samples as well.

Finally, it is not purposeful to allow learners to put themselves at risk at their own responsibility. Techno-Risk Tolerance in Technology Education (TE) should be assessed together with the learners. Immediate benefits such as learning new skills or producing innovative products motivate to take risks but facing the risks can also lead to failure. Living in the modern world of technology involves processing ethical questions that technological production activities can prepare learners for. Techno-Risk can be increasingly hidden in embedded systems and networks so pupils require more education in risk awareness in their technological activities. The key ideology of the late 20th century Safety Education was achieving zero risk but Safety Education of the 21st century should be aimed to educate to prepare for uncertainty of Techno-Risk.

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